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An Aid In Choosing the Right Tree To Leave

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A SLIDE-RULE DEVICE

THE SUCCESSFUL FOREST manager has a number of well-stocked stands containing trees that are sound, useful, and fast-growing. Each stand and each tree is increasing in value fast enough that its rate of earning equals or exceeds the earnings from comparable investments.

A growing stock of this kind is obtained by leaving the right trees when thinning or making a harvest cut. This paper has been prepared to describe an aid in choosing the right trees to leave.

For most trees the choice is obvious to the forester. Some trees are sound, straight, tall, and vigorous; and they are clearly wanted in the future stand. Others are defective, crowded, overmature, or otherwise undesirable elements of growing stock. In general, species, composition, stand structure, and quality will identify the trees that should be left to grow some more. Without any particular study,

these trees are known to be the ones that will increase the total value of the forest more than enough to earn the required return.

But in addition to these, there may be borderline trees that are difficult to decide about. In some stands there are so many good trees that growth would be impaired if all were left. More commonly today, trees of poor quality are so plentiful that it may be difficult to keep even a low level of growing stock. In either case, a determination of earning capacity should help in choosing the right trees to leave.

A slide-rule device has been prepared to help the forester make this choice. It permits a comparison of earning capacity based on present size and estimated growth. The tree to leave is the one with the greater earning capacity.

HOW IT WAS DEVELOPED

Earning capacity of a tree may be calculated from the compound-interest formula, or by use of tables. Either way is cumbersome and is subject to mistakes in application. One solution might be a series of tables such as Heiberg[1] has prepared for white pine. These tables are based on average value as a function of d.b.h. (diameter breast high). From these values Heiberg calculated growth rates required to earn different interest rates from a tree.

Study of the problem indicated that it should be possible to put the necessary information on a slide rule that you can carry in your pocket. A slide rule is a device that adds or subtracts graphically; so the scales would have to be graduated so that addition or subtraction would provide the desired answer.

This condition is satisfied if $\text{Value} = a\,(\text{DBH})^b$, which is a straight line in logarithms. In this equation, a and b are parameters that may vary with species, locality, and the physical relationship of the forest to the wood-using plant.

The slide rule was prepared for use with yellow-poplar in West Virginia. Holcomb's data[2] on value per tree

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[1]Heiberg, Svend O. Cutting based on economic increment. Jour. Forestry 40: 645-651. 1942.

[2]Holcomb, Carl J., and Bickford, C. Allen. Growth of yellow-poplar and associated species in West Virginia as a guide to selective cutting. Northeast. Forest Expt. Sta., Sta. Paper 52. 28 pp. 1952.

of yellow-poplar were used (table 1). They were plotted on double-log paper. Departures from a straight line were found to be trivial. Heiberg's data are similar.

The d.b.h. scale was graduated on the basis of logarithms of value, showing the diameter corresponding to an average value. The same scale, in logarithms, was used for $(1 + r)^n$, giving various values for r when n = 10, and for n when r = 0.03.

It should be noted that the data on value of yellow-poplar are adjusted for volume and quality, but not for influence of size on logging cost. Since cost per unit of volume tends to diminish with increasing d.b.h., this slide rule will tend to underestimate rate earned.

Estimated rate earned is subject to error because costs and prices may change. Actual net stumpage value may be affected by still other factors, such as accessibility. But for comparative purposes in choosing the right trees to leave, errors due to these factors are not important. The better tree to leave is still the one with the greater earning capacity.

HOW TO USE IT

The slide rule can be used to answer two questions:

1. What interest rate is earned by yellow-poplar trees of various sizes and growth rates during a 10-year period?
2. What growth is required to earn 3 percent (compounded) interest on trees of various sizes over different periods of time?

> NOTE
>
> A printed plan for the slide rule is attached to this report, with instructions so you can cut out the pieces and assemble it yourself.

To Figure Interest Earned

To figure interest earned by a tree, set 0 of the "Interest Earned" scale on the slide at present d.b.h. Add expected diameter growth to get an estimate of d.b.h. 10 years hence. Now read off the number on the slide corresponding to this estimated d.b.h. This is the rate earned.

Table 1.--Average volume and value of yellow-poplar in West Virginia

D.b.h. (inches)	Volume*	Value
	Board feet	Dollars
12	101	2.29
14	166	3.98
16	248	6.41
18	346	9.80
20	461	14.39
22	593	20.48
24	741	28.28
26	905	38.25

*International $\frac{1}{4}$-inch rule.
Source: Table 11 in Holcomb-Bickford report (see footnote 2).

Table 2.--Average d.b.h. growth of yellow-poplar during next 10 years, by vigor classes

Present d.b.h. (inches)	Vigor class			
	1	2	3	4
	Inches	Inches	Inches	Inches
12	2.9	2.1	1.4	0.7
14	2.8	2.1	1.4	.7
16	2.6	2.1	1.4	--
18	2.5	2.1	--	--
20	2.4	--	--	--
22	2.3	--	--	--
24	2.2	--	--	--
Average*	2.7	2.1	1.4	0.7

*Weighted average of measured trees of saw-timber size.
Source: Table 10 in Holcomb-Bickford report (see footnote 2).

D.b.h. is measured directly. For estimated diameter growth during the next 10 years, see table 2. In some cases vigor class alone may suffice. When average growth by vigor class is not decisive, average growth by d.b.h. class within a vigor class may provide a sharper comparison.

Increment boring can be used as a last resort. The increment core provides data on past growth, which can be used to estimate growth in the next 10 years (see formulas).

FORMULAS

<u>for estimating growth during next 10 years</u>

Vigor class 1 $\quad \Delta d_1 = 0.93 + 0.64\ \Delta d_2$

Vigor class 2 $\quad \Delta d_1 = 0.66 + 0.60\ \Delta d_2$

Vigor class 3 $\quad \Delta d_1 = 0.72 + 0.39\ \Delta d_2$

Vigor class 4 $\quad \Delta d_1 = 0.26 + 0.40\ \Delta d_2$

in which Δd_1 is estimated d.b.h. growth during next 10 years and Δd_2 is measured d.i.b. growth during last 10 years.

Some illustrations may be helpful:

- Suppose two yellow-poplar trees are neighbors and we decide to cut one to provide more growing space for the other. One is 18.4 inches d.b.h. and of vigor class 1; the other is 13.6 inches d.b.h. and of vigor class 2. The expected diameter growth of the two trees during the next 10 years (from table 2) is 2.5 inches and 2.1 inches respectively.

Now, using the slide rule, set 0 of the "Interest Earned" scale at 18.4 inches d.b.h. Estimated d.b.h. of the larger tree 10 years from now is 18.4 + 2.5 = 20.9; and the corresponding reading on the slide shows that this tree can be expected to earn 4.8 percent interest. In the same fashion, the smaller tree is found to have an expected interest rate of 5.4 percent.

Similar but less precise results are obtained by using the class average of 2.7 inches d.b.h. growth (table 2) in place

of the average of 2.5 inches for 18-inch trees. Midpoint of a diameter class might also be used, but any forest manager interested enough to want to use the slide rule should also measure d.b.h. to the nearest tenth of an inch and use that information.

In this example we have made no adjustment for the release effect expected from cutting one of the trees; yet it is evident that cutting the larger, more vigorous tree should bring about a greater growth response in the smaller tree than could be expected from the larger tree by cutting the smaller. So the smaller tree is the better to leave in this case.

- Now take two other trees, also neighbors. Both are vigor 1 trees, with no evident difference in quality or apparent vigor. One is 18.8 inches d.b.h., the other 20.2 inches. Table 2 shows that the smaller tree is growing faster. Use of the slide rule indicates this tree should be left.

But suppose each tree departed a little from the average--in favor of the larger tree. Suppose the marker subconsciously recognizes some indicator of exceptional growth, and bores the trees to find that the smaller grew 2.0 inches and the larger 2.4 inches (diameter inside bark) during the last 10 years.

Estimated d.b.h. growth during the next 10 years (from the formulas) is found to be 2.2 inches for the smaller tree and 2.5 inches for the larger. The slide rule now shows that there is a small advantage in leaving the larger tree.

To Figure Growth Required

To figure on the slide rule the growth required to earn 3 percent interest over a certain period of time, set 0 of the "Growth Required" scale on the slide at present d.b.h. Read off the d.b.h. that corresponds to the length of the growing period in years. This d.b.h., minus present d.b.h., is the growth required over that time period to earn 3 percent interest.

The slide rule may be used this way in choosing the trees to leave when accessibility, stocking, and perhaps other factors make it desirable to use cutting cycles of various lengths. Or when financial considerations may lead a forest manager to require a certain minimum return. (On this slide rule 3 percent is used; but obviously any other rate could be used.) In application, the trees to leave

should have an expected growth equal to or greater than the required growth indicated by the slide rule.

Other Applications

These two uses of the slide rule have been aimed at problems of managing all-aged stands on a cutting-cycle basis. The same procedures may also be used in thinnings or other partial cuttings in even-aged stands, in deciding on borderline trees.

The slide rule may also be used to determine when an even-aged stand is mature. In this case it is time to cut when the average rate earned falls below the required minimum.

USE WITH OTHER SPECIES OR IN OTHER LOCALITIES

The question naturally arises: Can this slide rule be used for other species or in other localities? The answer is yes if the yellow-poplar value data (table 2) apply. But in general, values for another species or for a different locality will be different.

If value over d.b.h. is a straight line on double-log paper, a similar rule can be prepared. If this straight line is parallel to that obtained by plotting the yellow-poplar data, this rule will be applicable. Parallel lines on double-log paper mean that the ratio of values by d.b.h. is constant. This is equivalent to multiplying all values by some common factor; so it does not change rate earned.

Another possibility is that, with larger trees of superior quality becoming scarcer and scarcer, there may be an increasing differential in favor of the larger trees. In this situation a new graduation of the diameter scales should be made, based on the appropriate value/d.b.h. relationship.

Returning to the question of other species, the value/d.b.h. relationship depends on average volume over d.b.h. and average value per unit of volume over d.b.h. When wood is used in a bulk product, such as pulp, there is less increase in value per cubic foot with increasing diameter. In this case, a useful rule for approximate purposes could be based on volume instead of value. It would be biased, of course, and should be used only until a better basis becomes available.

When wood is used for ordinary lumber, the increase in average value per tree with increasing d.b.h. is much steeper than when the trees are cut for pulp. And in like manner, the increase is steeper still when the larger trees are cut for some premium product such as face veneer. These factors would be important in preparing a similar rule for spruce in Maine, yellow birch in New York, and so on.

Agriculture - Forest Service - Upper Darby, Pa.

FRONT

D. B. H., IN INCHES

12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

CUT OUT THIS WINDOW

BACK

NORTHEASTERN FOREST
EXPERIMENT STATION
UPPER DARBY, PA.
1953

SLIDE RULE

FOR CHOOSING TREES TO LEAVE
IN SELECTIVE CUTTING

FOR YELLOW-POPLAR
IN WEST VIRGINIA

SLIDE

0 2 3 4 5 6 %

INTEREST EARNED
IN 10 YEARS

0 5 10 15 20 YEARS

GROWTH REQUIRED
TO EARN 3%

INSTRUCTIONS FOR ASSEMBLING

1. Cut out FRONT and BACK.

2. Cut out window in FRONT.

3. Fasten FRONT and BACK together by taping side edges, allowing space for slide. Leave ends open.

4. Cut out SLIDE and insert so printed scale appears in window. If necessary trim edges till it slides freely.